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COURSES OF STUDY

GRADE XIII

BIOLOGY

These revised Courses, introduced in September 1954, replace those contained in Circular H.S. 23, last printed in 1950.

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BIOLOGY

GRADE XIII

There are two main objectives in teaching Botany and Zoology in Grade XIII: first, to provide some general knowledge for those who will not study these subjects further and, second, to provide a good foundation for those who will proceed to advanced work.

Every effort should be made to relate the factors common to both plant and animal life; the unit cell, the assimilation of food materials, the various physiological processes, the principles of genetics, and to show the dependence of animal life on plant life, and the interdependence of all forms of life.

Related species not included for special study may be brought to the attention of pupils when they are of special local significance or interest.

Systematic notebook records and observational drawings or diagrams are essential.

The number of periods indicated (each of approximately 35 to 40 minutes), is merely a suggestion or a guide to the depth of treatment.

BOTANY

The course is intended to give pupils an understanding of the more important divisions of the plant kingdom and the various functions performed by the parts of the plant. The economic importance of plants, the balance of nature, and the cycles of the constituent elements should be stressed.

The observation of living plants is essential and may be fostered by field trips in the fall and in the spring for observation of plants in their natural habitats and to collect specimens for an herbarium or for preserving otherwise. The use of the simple and the compound microscope is essential in observing microscopic forms and plant tissues and cells.

Except in the study of certain angiosperm flowering plants for the purpose of classification, it is suggested that the sequence of topics in this outline be followed so that pupils may better understand the development from lower to higher forms of plant life.

OUTLINE OF THE COURSE

The Cell
(Six periods)

Microscopic study of a normal plant cell—(Elodea, Spirogyra, Zygnema, or any other single plant cell) including cell wall, protoplasm, nucleus, cytoplasm, cytoplasmic membrane, plastids, starch grains and vacuole.

Mitosis—description and diagrammatic representation of cell division, (phase names not required).

Entry and exit of materials—Review diffusion (Grades XI and XII Chemistry); simple experiments to illustrate (a) osmosis and (b) plasmolysis of a cell. Reference to turgor and plant-wilting; application of diffusion and osmosis to photosynthesis and respiration.

Thallophytes
(Three periods)

Algae, Spirogyra: (a) Habitat, (b) Cell structure, (c) Reproduction: fragmentation and conjugation. Reference only to other algae, both unicellular and multicellular.

(Three periods)

Bacteria: (a) Habitat, (b) Forms, (c) Reproduction, (d) Beneficial effects (soil fertility, decay, making of vinegar, souring of milk, "ripening" of cheese, curing of tobacco, and ensilage); (e) Harmful effects, diseases and spoiling of food; (f) Carbon and nitrogen cycles.

(Four periods)

One of Apple Scab, or Black Knot; and one of Wheat Rust, or Pine Rust. Life cycle, economic importance and control.

(One period)

Lichen: (a) Habitat; (b) Types: crustose, foliose, and fruticose; (c) Structure of a lichen noting the symbiotic relationship between an alga and a fungus, stressing the protective and nutritive roles of the fungus and alga, respectively; (d) Role in plant succession as pioneers on rocks.

Bryophytes
(Three periods)

Moss: (a) Habitat, (b) Structure and reproduction: (i) gametophyte (haploid phase), general features of the stem and leaves of the "moss plant," rhizoids, terminal archegonia and antheridia, motile sperms, and egg; (ii) sporophyte (diploid phase),—foot, stalk, and capsule (operculum and peristome); fusion of sperm and egg, zygote, spore mother-cells, reduction division to spores, protonema, fragmentation, buds and gametophyte plant (haploid phase).

The Liverwort may be substituted for the moss.

Pteridophytes
(Four periods)

The Fern: (a) Habitat, (b) Structure and reproduction: (i) sporophyte (diploid phase), rhizome, frond (rachis and pinnae), vernation, sori, indusium, sporangium, and annulus; spore mother-cells, reduction division to spores; (ii) gametophyte (haploid phase), prothallium, rhizoids, antheridia, archegonia, motile sperms, fusion of sperm and egg, zygote, embryo sporophyte, mature sporophyte and fragmentation of rhizome.

Recognition only of Equisetum (horsetail), Lycopodium (club moss), and Selaginella.

Comparison of Bryophytes and Pteridophytes noting

similarities in life history such as alternation of generations, independence of gametophyte, necessity of water for fertilization, sexual organs; and such differences as increasing complexity (development of mechanical, vascular, absorptive and food-manufacturing tissues) and independence of the sporophyte of Pteridophytes.

Spermatophytes
Gymnosperms
(Five periods)

The Pine: (a) Habitat; (b) General characteristics of pine tree (sporophyte)—leaves, (clustered, thick cuticle and depressed stomata); male or staminate cone (pollen-bearing, axis, microsporophyll, microsporangia or pollen sacs); female or carpellate cone (seed-bearing, axis, scale-like megasporophyll, bract, megasporangia or ovules, and single integument); (c) Life cycle: mature sporophyte (diploid); (i) male cone—microspore mother-cell, reduction division to microspore (wind pollination), male gametophyte, antheridial cell, generative cell, pollen tube, sperms and fertilization; (ii) female cone—megaspore mother-cell, reduction division to megaspore, female gametophyte (endosperm), archegonium, egg, fertilization, zygote, seed (three to eight cotyledons), seedling, and mature sporophyte.

Note: *Macrospore equivalent to megaspore.*

Angiosperms
The Flower
(Six periods)

The essential and accessory parts of the flower with their functions: complete and incomplete, perfect and imperfect flowers; adhesions of flower parts, superior (hypogynous), inferior (epigynous), perigynous, epipetalous.

A study of one representative of each of the following families: Ranunculaceae or Cruciferae, Compositae, Aceraceae or Rosaceae, and one member of Solanaceae or Scrophulariaceae. A detailed study of the flower should be made in each case, together with the features of leaf, inflorescence and fruit, where these are important as family characteristics.

(One period)

Study of a flower of oat or wheat (Gramineae).

Consideration of the flower structure from observation or diagram. Economic importance of the grass family (wheat, oats, barley, rye, corn, pasture and lawn grasses).

Pollination
(Three periods)

Microscopic study of pollen grains; cross- and self-pollination; agents of pollination; adaptations of flowers for wind and insect pollination; adaptations for cross-pollination—imperfect flowers, dichogamy, sterility of pollen, shape of flower; advantages and disadvantages of cross- and self-pollination; artificial pollination.

Fertilization
(Two periods)

Changes following pollination and prior to fertilization (germination of pollen grain; ovule structure); fertilization and double fertilization; and subsequent development (seed and fruit formation). (Actual fusion of male and female gametes).

The Fruit
(Three periods)

Structure, derivation and examples of the following fruits: achene, grain, samara, legume, capsule, berry,

pome, and drupe. Distinguish types of fruits—simple, aggregate, and multiple; fleshy or dry (dehiscent and indehiscent).

The Seed (Four periods)

Practical study of corn grain, and bean seed—external and internal views. Parts and functions of the corn; ovary wall, seed coats (protection), endosperm (food for embryo); embryo; cotyledon; plumule, hypocotyl, and radicle. Similar treatment of bean seed, stressing that it has two cotyledons in the embryo and lacks an endosperm in the mature seed.

Demonstration of germinating seeds and seedlings.

(One period)

Reference to differences between angiosperms and gymnosperms—the gametophyte less developed and specialized, development of ovary wall, double fertilization, development of endosperm, seeds with one or two cotyledons, and the flower, the organ of sexual reproduction.

Reference to advances of Spermatophytes over Pteridophytes (a) pollen tube (obviates need for water) and (b) the seed habit (dissemination, protection of embryo, dormancy, food for embryo and natural improvement of varieties through selection).

CONQUEST OF THE LAND BY PLANTS

Throughout the survey of the plant kingdom attention should be paid to the conquest of the land by plants. Primitive plants use water for fertilization and water is not available to large land plants for this purpose. The sporophyte generation produces dry spores which multiply the species but do not involve the sexual reproduction which is advantageous in bringing in new "blood," i.e., in combining useful hereditary qualities from different parents.

On land the sporophyte became larger and more successful and the gametophyte smaller. Heterospory, the retention of the megaspore and its product the female gametophyte, together with the development of the pollen tube from the microspore (pollen grain), overcame the obstacle of lack of water for motile sperms and made possible the great development of seed plants on land. In Angiosperms the elaboration of flowers and the enclosure of the ovule (megasporangium) by the megasporophyll (carpel) producing the fruit, have made these plants the most wide-spread and successful of the whole plant kingdom and have resulted in the complete conquest of the land wherever life can exist.

Structure and Function The Root (Five periods)

Study of root tip as shown in rooted cuttings (geranium) or seedling (radish or timothy).

Experiment to show region of elongation in a root tip. Microscopic study of (a) longitudinal section of root tip, noting the function of each part; (b) cross section of young root in the root-hair zone indicating epidermis, cortex, endodermis, stele (pericycle, phloem, xylem, par-

enchyma). Give the function of each of the parts. Discuss differentiation of parenchyma cells into vascular tissue.

Root-hairs—origin, location, structure, duration, and function.

Development of branch roots; secondary thickening (cambium).

Function of roots—(a) primary (anchorage, absorption of water and mineral salts, and conduction); (b) special (storage, propagation, and parasitic habit).

The Stem
(Nine periods)

Classification of trees as to form (excurrent and deliquescent). Examination of green and woody shoots to show growing points, arrangement of leaves, buds, branches, nodes, lenticels, leaf-scars, and bud-scale scars. Microscopic study of a cross-section of a herbaceous dicotyledonous stem showing epidermis, cortex, pericycle, vascular bundle (phloem—sieve tubes and companion cells; cambium and xylem—tracheae or vessels, tracheïds); pith ray, and pith. Discuss differentiation of cells and their organization into conducting, mechanical, and storage tissue. Primary and secondary growth, annual rings, grain in wood.

Cross-section of monocotyledonous stem (corn) as seen under the low-power microscope indicating epidermis, parenchyma, vascular bundles (phloem—sieve tubes and companion cells; xylem—tracheae or vessels, tracheids; bundle sheaths).

Functions of stems—(a) general: production of buds and support of leaves, flowers, fruits, and seeds; conduction of water and food; (b) special reproduction (cuttings and grafting); photosynthesis; storage (rhizome, tuber, corm, and bulb); climbing (twining stems); protection (thorn).

Experiments to show responses to gravity and light.

Reference to other stimuli—touch, moisture.

An experiment to show the region of elongation of an herbaceous dicotyledonous stem.

Comparison of roots and stems under the following headings: protection of growing points, tropisms, absorption organs, branching, and nodes; similarity of secondary growth in both.

The Leaf
(Thirteen periods)

External features—blade, petiole, stipules, compounding, and venation. Microscopic study of (a) a cross-section of a leaf indicating cuticle, epidermis, guard-cells, stomata, mesophyll (palisade and spongy tissues), air-spaces and veins; (b) a leaf epidermis to show epidermal and guard-cells. Reference to the opening and closing of these stomata.

General functions of the leaf—(a) Photosynthesis—chlorophyll, raw materials, energy source, and products. Experiments to show that (1) starch is manufactured by green tissues during light exposure; (2) oxygen is released; (3) chlorophyll is necessary; (4) carbon dioxide is essential for photosynthesis.

(b) **Respiration**—Experiment on germinating seeds to show that carbon dioxide is produced. Discuss respiration in leaves. Contrast photosynthesis and respiration under the following headings: energy change, raw materials, times of occurrence, cells involved, and products.

(c) **Transpiration** — Experiment to demonstrate water loss. Conditions affecting transpiration rate: (1) leaf structure and habits (leaf thickness, leaf area, cuticle, stomata, leaf fall, and leaf curling); (2) light and heat; (3) evaporating power of the air; (4) water content of the soil. Application of some of these factors in transplanting.

Special functions of the leaf—storage, propagation, protection, climbing, and capture of insects.

Fall of the leaf—The role of cork cambium and abscission layer; deciduous and evergreen habits. Significance of colour changes.

Ecology
(Six periods)

Relation of plants to their environment with regard to the following factors:

(a) **Climatic:** light, (leaf structure of sun and shade plants, time of flowering, photoperiodism, temperature, wind, humidity and precipitation).

(b) **Edaphic:** brief reference to soils; origin, texture classification, air in soil, water in soil, soil temperature.

(c) **Biotic:** competition among different species of plants, grazing, parasitic diseases (reference to examples), harmful and beneficial insects (examples only), soil bacteria (reference to nitrogen-fixing and denitrifying bacteria), earthworms (aerating, grinding and enriching the top layer of earth).

(d) **Water:** relation of structure of (mature) plants to their environment as in xerophytes, hydrophytes, mesophytes.

Genetics
(Eight periods)

A discussion of the relative effects of environment, (nutrition, light, water), and heredity on the growth of animals and plants.

Consideration of conditions for the study of heredity:

(a) Environment does not explain why (i) offspring resemble parents, (ii) offspring are not exactly like their parents.

(b) Mendel's experiments with pea plants of contrasting characters to show (i) that the first generation following a cross is like one parent, (ii) that the members of this generation crossed among themselves give offspring showing the ratio 3:1 and that the dihybrid cross gives the folowing ratio: 9:3:3:1.

(c) Explanation of above in terms of (i) dominant and recessive characters, (ii) segregation.

(d) Blending or incomplete dominance—snapdragon, four o'clock. Quantitative inheritance.

(e) A consideration of the chromosome theory of inheritance and the gene; reference to cell division

(mitosis) and chromosome reduction (meiosis), noting the gene consitituions of the parents and gametes in both pure breeds and hybrids.

(f) Mendelian inheritance in man in relation to eye colour, hair colour, skin colour.

Total 90 periods

(g) The sex ratio, (x and y chromosomes).

ZOOLOGY

(One period)

It is suggested that at the beginning of the course the teacher should give some time to the following: an introduction to some of the functions common to all animals such as food-getting, digestion, circulation, respiration, excretion and reproduction; brief reference to the increasing complexity of animals from the Protozoa, in which all the functions of life are performed by the single cell, to the most complex in which there is specialization of parts for particular functions; difference in structure for performance of some function, as in fins, wings and legs for locomotion, lungs and gills of different kinds for respiration; basic similarities in the behaviours and functioning of all animals in the maintenance of their individual existence and the perpetuation of the species; individuality of the living organism, each a going concern making adjustments with its constantly varying environment and each, therefore, with some mechanism of response and adjustment to the stream of incoming stimuli.

The following should be kept in mind in teaching the course:

(1) There should be a study from actual observation of the external features and habits of many forms, and of appropriate dissections (where the anatomy, viscera, mouth parts, etc. are called for).

(2) The use of the microscope, the operation of a "balanced" aquarium, and a vivarium in the laboratory, and one or two field trips in the fall and spring should be essential features of the course.

(3) The order followed in the outlines is from lower to higher forms. The teacher may take different topics in relation to the availability of materials but the place of each topic in the general plan should be always related.

OUTLINE OF THE COURSE

Invertebrates
Protozoa
(Four periods)

The unicellular animals. A study of the amoeba or paramoecium as an example of an animal in which all of the functions of life are performed by the single cell. A practical study of the living animal under the microscope. The discussion of habitat; movements; structure of cell (nucleus, contractile vacuole, food vacuoles, ectoplasm, endoplasm, and pseudopodia or cilia); and functions (food getting, digestion, egestion, assimilation, excretion, respiration, growth, and reproduction).

Coelenterata
(Two periods)

A study of a living hydra to illustrate a very simple type of many-celled animal—food getting, digestion, respiration, excretion, reproduction, movement and response (sensitivity).

Annelida
(Seven periods)

Study of an earthworm as a type of animal in which the body is divided into a series of similar rings or segments in which some of the internal organs are repeated

in many of the segments. Study of the living animal—habitat; habits; external features (shape, covering, segmentation, clitellum, openings, and setae); and locomotion. Dissection to show the internal structure (digestive organs, dorsal vessel, "hearts", reproductive organs, septa, and nerve cord). Recognition of the bisexual nature of the animal. The names and functions of the chief digestive organs. A study with the low-power of the microscope of a cross-section posterior to the gizzard noting the cuticle, body wall, setae, muscles, blood vessels, intestine, typhlosole, nerve cord, and nephridia. Respiration (thin moist skin, richly supplied with capillaries).

Arthropoda

The most successful phylum of animals from the point of view of variety of kinds and number of individuals, man's most serious competitors for the supremacy of the earth.

Crustacea
(Six periods)

A study of living crayfish to illustrate a body organization on an entirely different basis from that of any other phylum of animals. Natural habitat. Study of living crayfish in an aquarium noting the habits of feeding, breathing, locomotion, swimming, and walking. The external features—body divisions, segmentation, covering, sense organs, serial homology of appendages as illustrated by the swimmerets, legs, and uropods.

Breathing: nature and location of gills, water movements, and gas exchange. Life History: eggs, care of young, and frequent moulting.

Insecta
(Eight periods)

The most successful of the arthropods. Review of the external features of an insect. A study of three insects to illustrate the similarities and differences in the external features of the adults with special reference to wings and mouth parts as a basis for illustrating classification into orders:

May beetle (Coleoptera) or ichneumon fly (Hymenoptera) Monarch butterfly or tent caterpillar (Lepidoptera) dragonfly (Odonata) or squash bug (Hemiptera).

Complete and incomplete metamorphosis. Life histories of the insects selected above: egg (where and when laid); larva or nymph (habitat, food and feeding habits, breathing; approximate time spent in this stage); pupa (habitat and time spent in this stage).

Vertebrates

Fishes, amphibians, reptiles, birds and mammals. Throughout the study of the five classes of vertebrates to be considered, the presence of a skull and a backbone, and the possession of two pairs of appendages should be noted in contrast to the absence of these features in the different phyla of invertebrates studied.

Pisces
(Seven periods)

Fishes. The practical study of living fish (a perch or goldfish) to show the movements associated with breathing, locomotion, balancing, and feeding. The external features with special attention to adaptations to environment and habits. These should include shape, colour, cov-

ering, organs of locomotion, and external sense organs.

Breathing organs; situation; number; parts; functions of parts; and such significant characteristics of the filaments as their thin covering, large surface, abundant capillaries, and means of protection.

Circulation: single circuit from heart to gills to body to heart. The course of the blood is to be traced through the heart to the gills and to the dorsal blood vessel noting the nature of the blood (rich in nutriment, deficient in oxygen) passing through the heart.

Life History: favourable breeding grounds; eggs (very numerous, fertilized after laying, large yolk); and high mortality. (The cleavage stages are to be omitted).

Amphibia
(Ten periods)

The practical study of a living frog to show movements associated with breathing (throat, nostrils, and sides); feeding (head, mouth, and tongue); and locomotion (swimming, jumping, crawling, diving, and burrowing).

Note—the toad may be used for some of the above observations.

The microscopic (low-power) observation of the flow of the blood (plasma and corpuscles) in the web of the foot (or in the tail of the tadpole).

External features—shape, moist skin, large mouth, nostrils, eyes, ears, and limbs.

Dissection from the ventral aspect.

The location and function of the chief organs of:

Respiration—lungs, nostril, mouth, trachea, lining of the mouth, and skin.

Digestion—mouth, gullet, stomach, intestine, liver and pancreas.

Excretion—kidneys, ureters, lungs, and skin.

Reproduction—testes, ureters, ovaries, oviducts, and cloaca.

Circulation — incomplete double circulation, three-chambered heart, truncus arteriosus, and its three main branches. (The venous system is not required).

Nervous system—dorsal view of brain (olfactory lobes, cerebrum, optic lobes, cerebellum, medulla); spinal cord; and spinal nerves (number, relationship to vertebrae, and fusions to form brachials and sciatics).

Life History—spawning, fertilization, egg, zygote, cleavage (2,4,8 and many cells), layers (outer, inner and middle), the fact that the organs and tissues develop from these layers. The tadpole, transformation to the adult noting the changes in the feeding, breathing and locomotion habits which accompany structural changes.

Repitilia
(Two periods)

Reptiles. Study of a living turtle or snake as examples of the class Reptilia which, although superficially resembling amphibians in a numbers of respects, is basically different in that the young do not have an aquatic stage. External features—shape, colour, covering, eyes, nostrils, and tongue. Locomotion.

Brief reference to other types of reptiles including prehistoric forms.

Aves
(Five periods)

Birds. Adaptations to flight with special reference to modification of front limb for flight; shape; covering (streamlining, decreased density, tail quills, and wing quills); skeleton (light bones which are thin or hollow, strengthening of shoulder regions, fingers reduced, fusing and lengthening of "hand" and wrist bones, "hand" bent back, ribs braced, sternum and keel enlarged for attachment of muscle, rigidity and flexibility of various regions of vertebral column); breathing (lungs, air sacs, and synchronization of breathing and flying movements).

Dissection from the ventral aspect to show organs of digestion and their functions.

Study of the skeleton should be based on a mounted skeleton or bones prepared for the purpose.

Mammalia
(Four periods)

Mammals. Study of a mammal (cat, rabbit, rat or other typical mammal of suitable size) to illustrate the characters of the most advanced type of vertebrate. Warm-bloodedness of birds and mammals compared with cold-bloodedness of fishes, amphibians and reptiles; production of milk by females for nourishment of young; covering of hair or fur.

A study of any mammalian skeleton: nature (bone and cartilage) and function (support, protection and attachment of muscle).

Skulls—many bones, large cranium, large eye orbits, occipital condyles and foramen magnum.

Vertebral column—description of a typical vertebra, five main regions of vertebral column pointing out modification in size and form of vertebrae.

Pectoral girdle—scapulae and clavicles.

Bones of fore limbs (little or no fusion).

Pelvic girdle—names and situation of bones.

Bones of hind limb—note similarity of plan of hind and fore limb.

The main characteristics with examples of the following orders:

Rodentia—typically vegetarian, incisors (chisel-shaped, self-sharpening and continuously growing), canines absent, and molars (broad and grooved).

Carnivora—small incisors, large interlocking canines, shearcutting molars, and feet usually provided with claws.

Ungulata—grinding molars, and feet with hoofs.

Primates—development of erect attitude, superior brain development, eye orbits directed forward, forelimbs fitted for grasping, and usually flat nails instead of claws.

(Four periods)

Dissection from the ventral aspect to identify the organs of digestion, respiration, circulation, excretion and reproduction as a basis for understanding references in succeeding topics in human physiology.

Human Physiology
(One period)

Organization of the body into cells, tissues, organs, systems.